DEMO PLANT OF CO_2 SEPARATION AND CONVERSION

Dr Jae-Goo Shim
Senior Member of Technical Staff, KEPRI
Korea Electric Power Corporation (KEPCO)
Korea

Demo Plant of CO_2 Separation and Conversion

ABSTRACT

Jae-Goo Shim*, Byung-Yeon Min, Jae-Keun Lee, Ji-Ho Yoon and Hee-Moon Eum

Radiation & Environment Group, Korea Electric Power Research Institute (KEPRI), Daejeon 305-380, Korea

To keep in step with international trend and to reduce the emission of CO_2 at thermal power stations, KEPCO/KEPRI(Korea Electric Power Corporation/Korea Electric Power Research Institute) has implemented environmental protection program to control CO_2 in the flue gas from 1996. The major action to reduce CO_2 emitted from thermal power station is the fabrication of separation and conversion pilot plant.

This paper describes the status of CO_2 separation and conversion technology in KEPCO/KEPRI. In addition, general information on climate change and global warming caused by greenhouse gas will be discussed.

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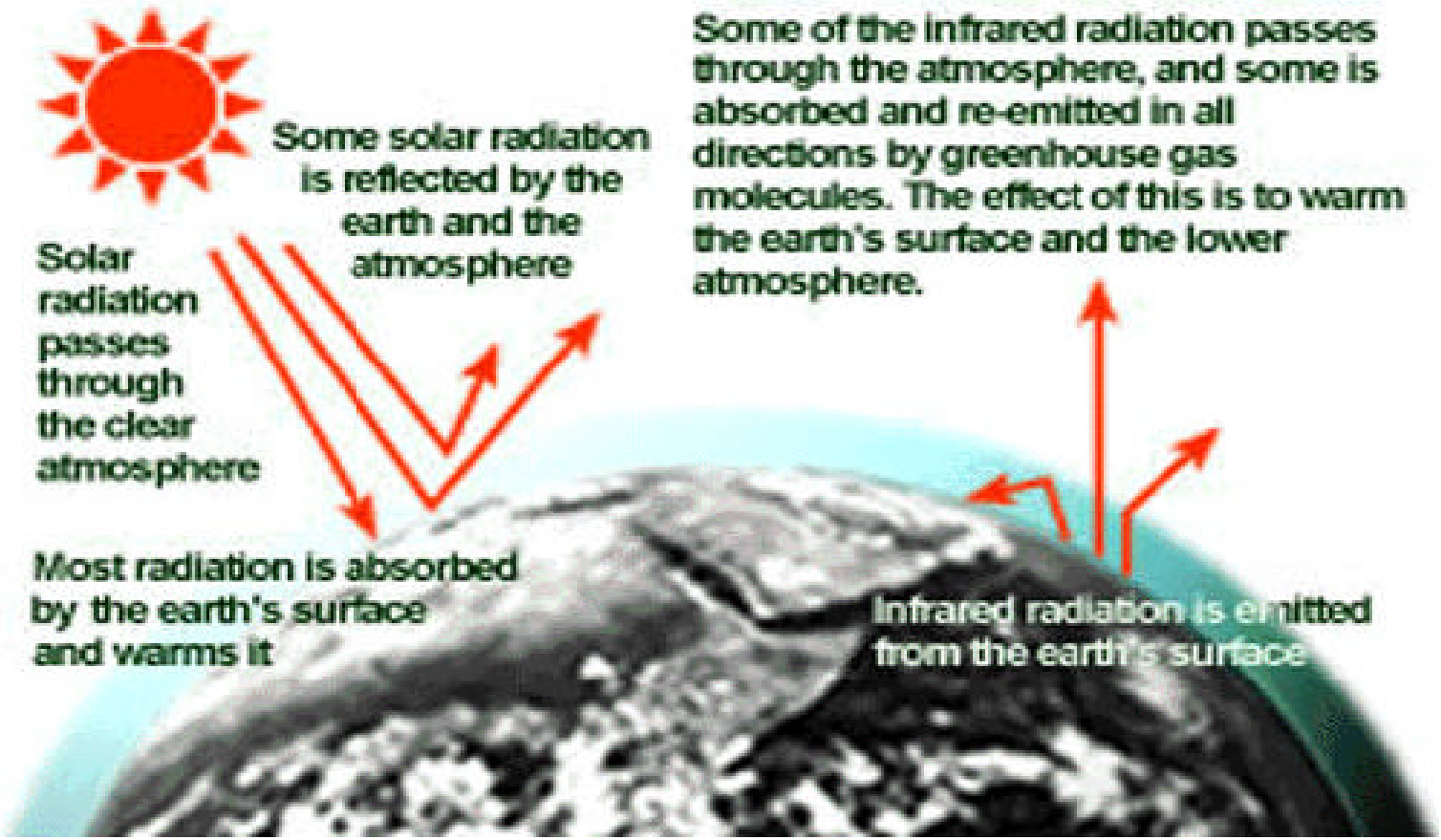
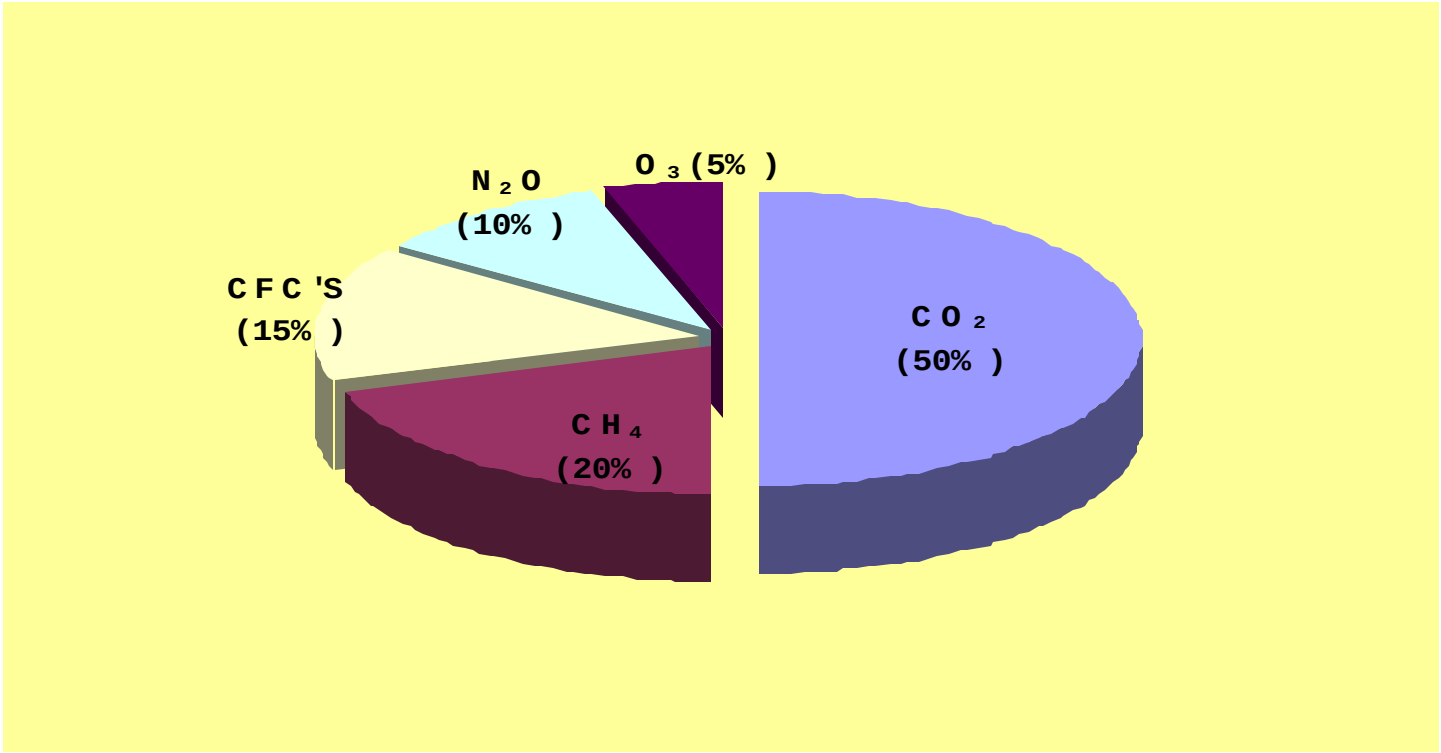
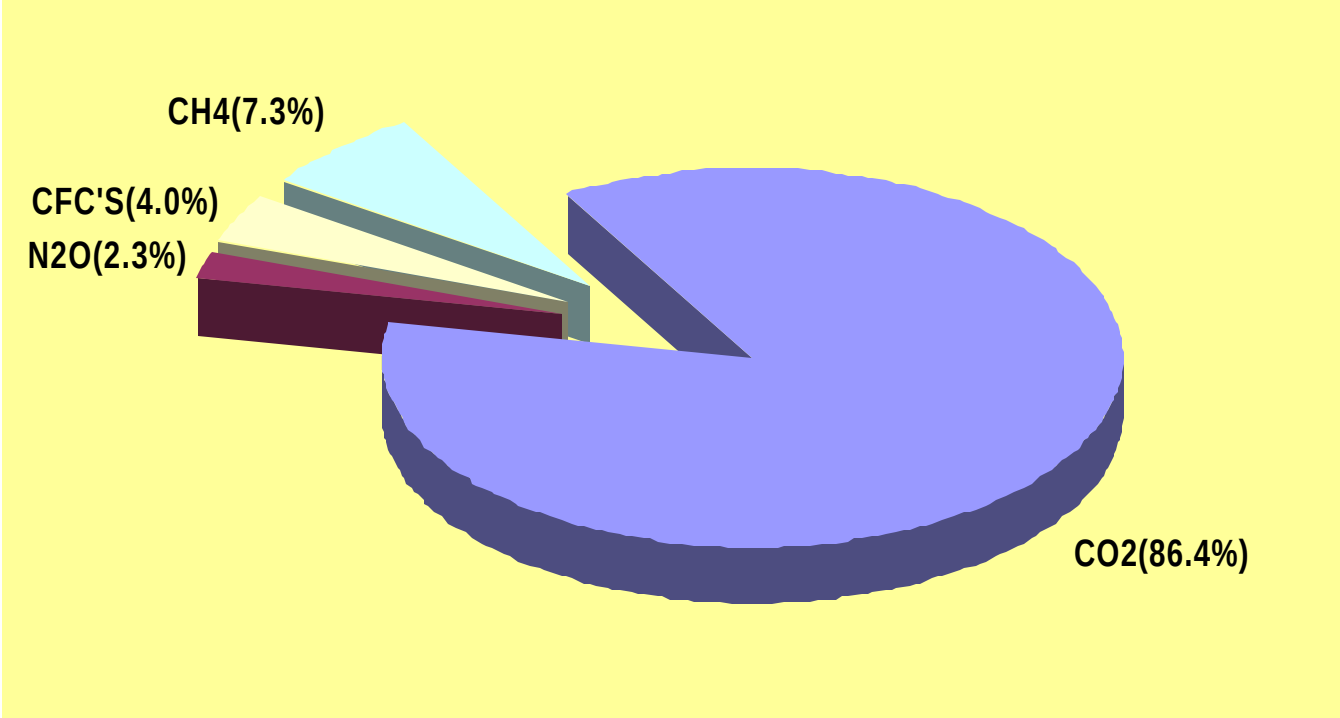
The Greenhouse Effect



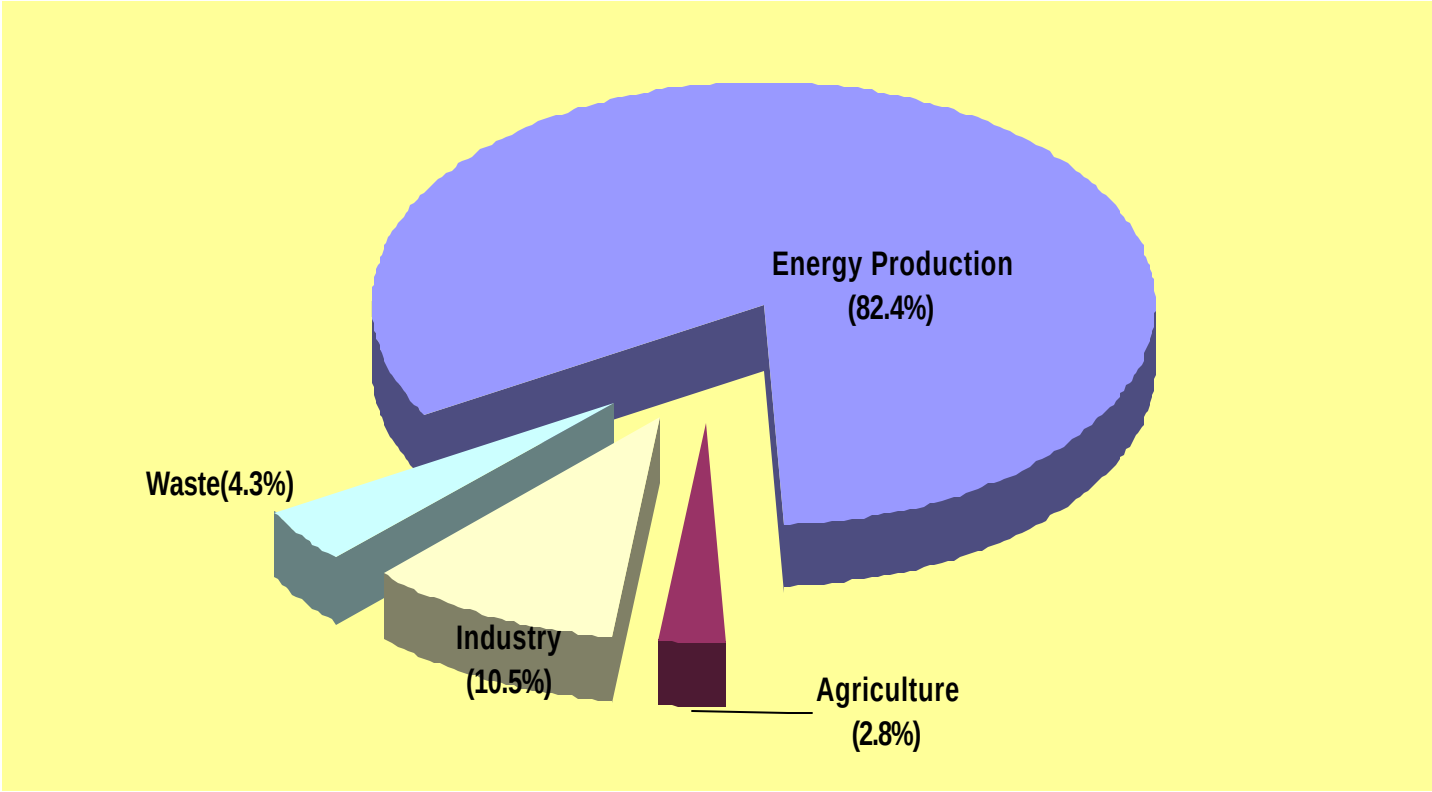
Global Warming Contributed by Greenhouse Gases



Emission Ratio of GHG in Korea



GHG Emission Source in Korea (1999)



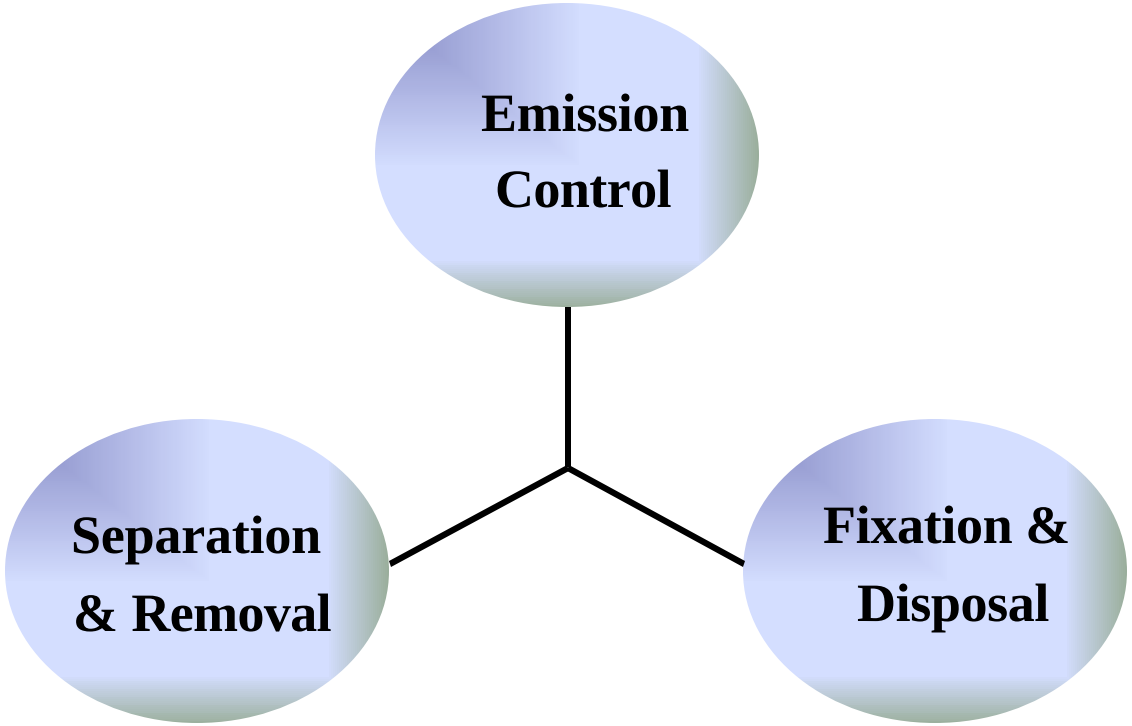
Environmental Changes Caused by Global Warming

according to IPCC* report

1. Increasement of the surface temperature
2. A rise of seawater level
3. Agricultural damage
4. Ecological adaptation
5. Reduction of the forestry area
6. Increasement of the disaster

*** IPCC : Intergovernmental Panel on Climate Change**

Carbon Dioxide Reduction Technology



CO_2 Reduction Technology at Electric Company

1. Elevation of T/P efficiency
2. Construction of highly efficient T/P
3. Operation of the less CO_2-emitted T/P (LNG > Oil > Coal)
4. Development of new and reusable energy
5. Energy saving and the development of power saving facility

Clean Energy Project*

- Title of the Project :

  A demo-plant study of CO_2 separation and chemical transformation
- Period of the Project :

  2000.01 - 2002. 12 (36 months)
- Main Research Institute : KEPCO (KEPRI)
- Project Team : Environment-Chemistry Group (KEPRI)
- Sub Research Institute : KAIST, KIER, KIST

* Supported by Korean Government

Objectives

- Development of a novel CO_2 separation process for thermal power plants
- Chemical transformation of CO_2 into methanol in pilot plant

Accomplished works

- Development of CO_2 separation technology by absorption
  - Development of a new absorbent :
    2-amino-2-methyl propanediol (AMPD)
  - Measurement of solubility & absorption rate of absorbents
  - Preparation & operation of lab scale CO_2 separation process (1 Nm_3/hr)

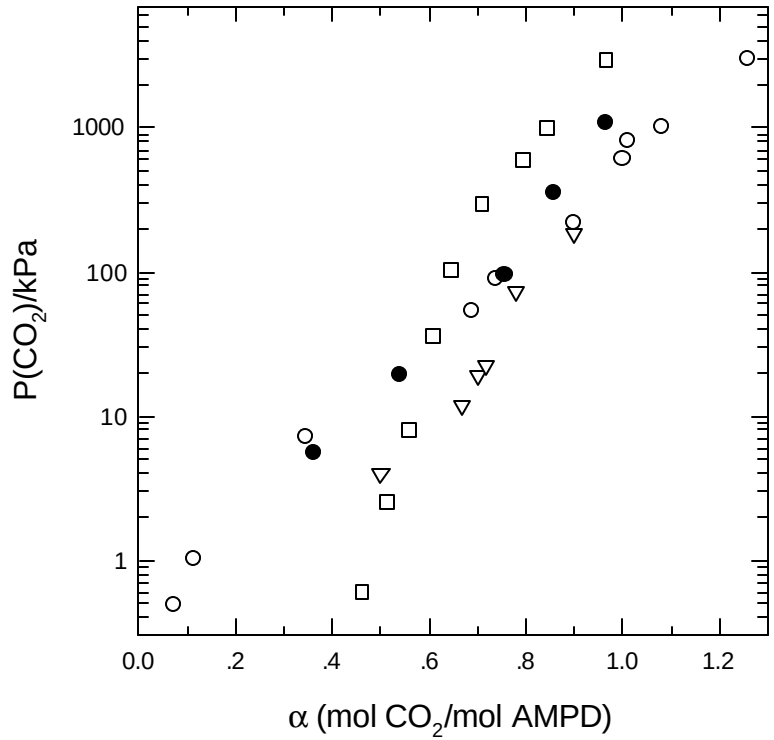
to be continued...

continued ….

- Improvement of CO_2 absorbents
  - Simulation of separation process using TSWEET
  - Preparation of a wetted wall column absorber to study the absorption ability of absorber types

- Study of the bench scale CO_2 separation process
  - Operation of CO_2 separation process (2 Nm^3/hr scale of flue gas)
  - Study on the effect of packing structure
  - Investigation on the thermal degradation of absorbents
  - Study on the scale-up factors for pilot-plant

Development of A New CO_2 Absorbent



- **Solubility of CO_2 in 30 % alkanolamine aqueous solution at 40 :**

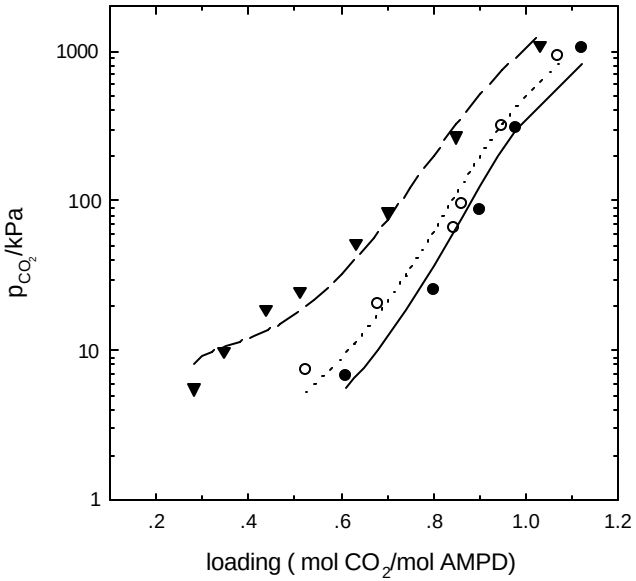
( ) AMPD (this work);

( ) MEA (Jou et al., 1995);

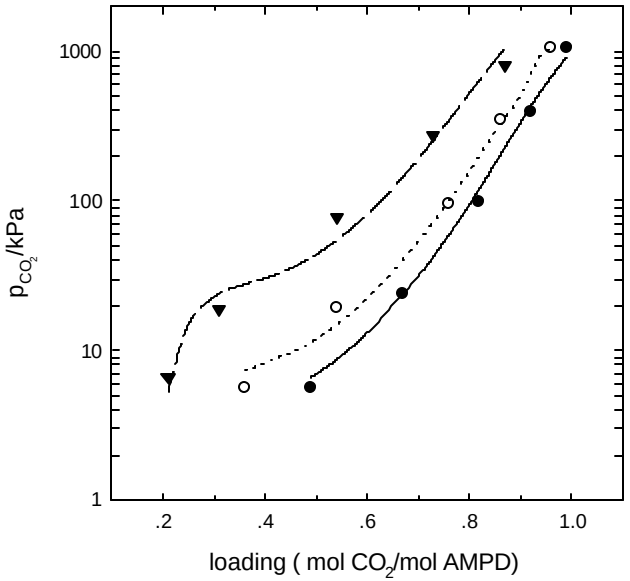
( ) MDEA (Jou et al., 1994);

( ) AMP (Seo and Hong, 1996)

Estimates of CO_2 Solubility by Modified Kent-Eisenberg Model



Solubility in 10 wt % AMPD solution by modelling.
30 ˚C (●) , 40 ˚C (❍) , 60 ˚C (♦)



Solubility in 30 wt % AMPD solution by modelling.
30 ˚C (●) , 40 ˚C (❍) , 60 ˚C (♦)

Reaction Mechanism

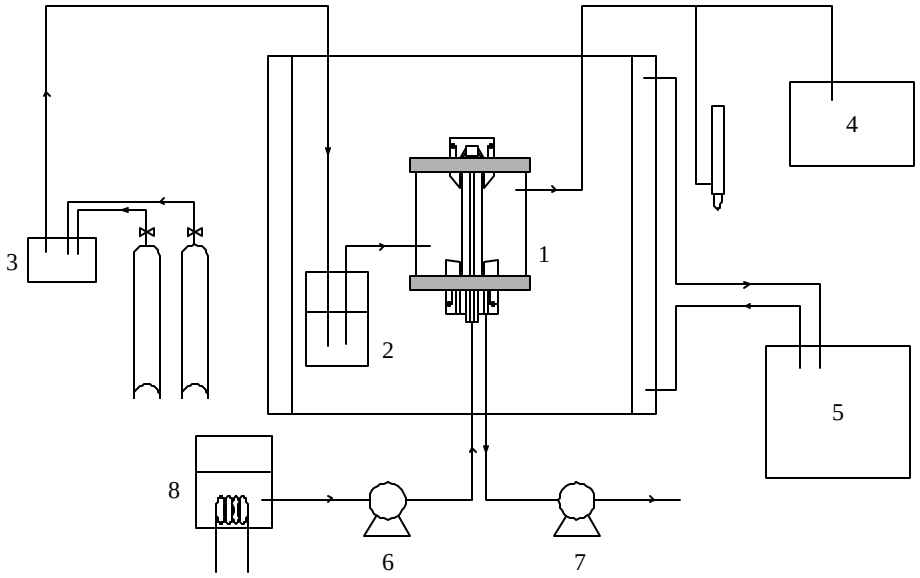
Primary & Secondary Amine

- ✓ Absorption : $CO_2 + 2RNH_2 \leftrightarrows RNHCOO^- + RNH_3^+$
- ✓ Stripping : $RNHCOO^- \leftrightarrows RNH^- + CO_2$

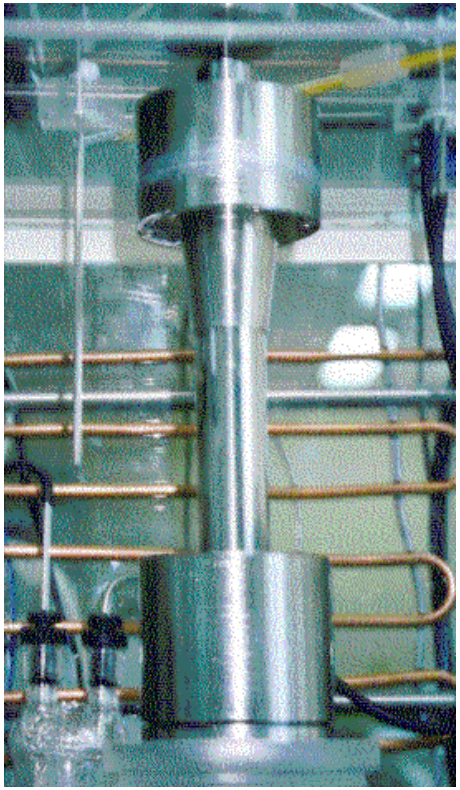
Tertiary Amine

- ✓ Absorption : $CO_2 + H_2O + R_3N \leftrightarrows HCO_3^- + R_3N^+H$
- ✓ Stripping : $HCO_3^- \leftrightarrows OH^- + CO_2$

Wetted Wall Column Absorber

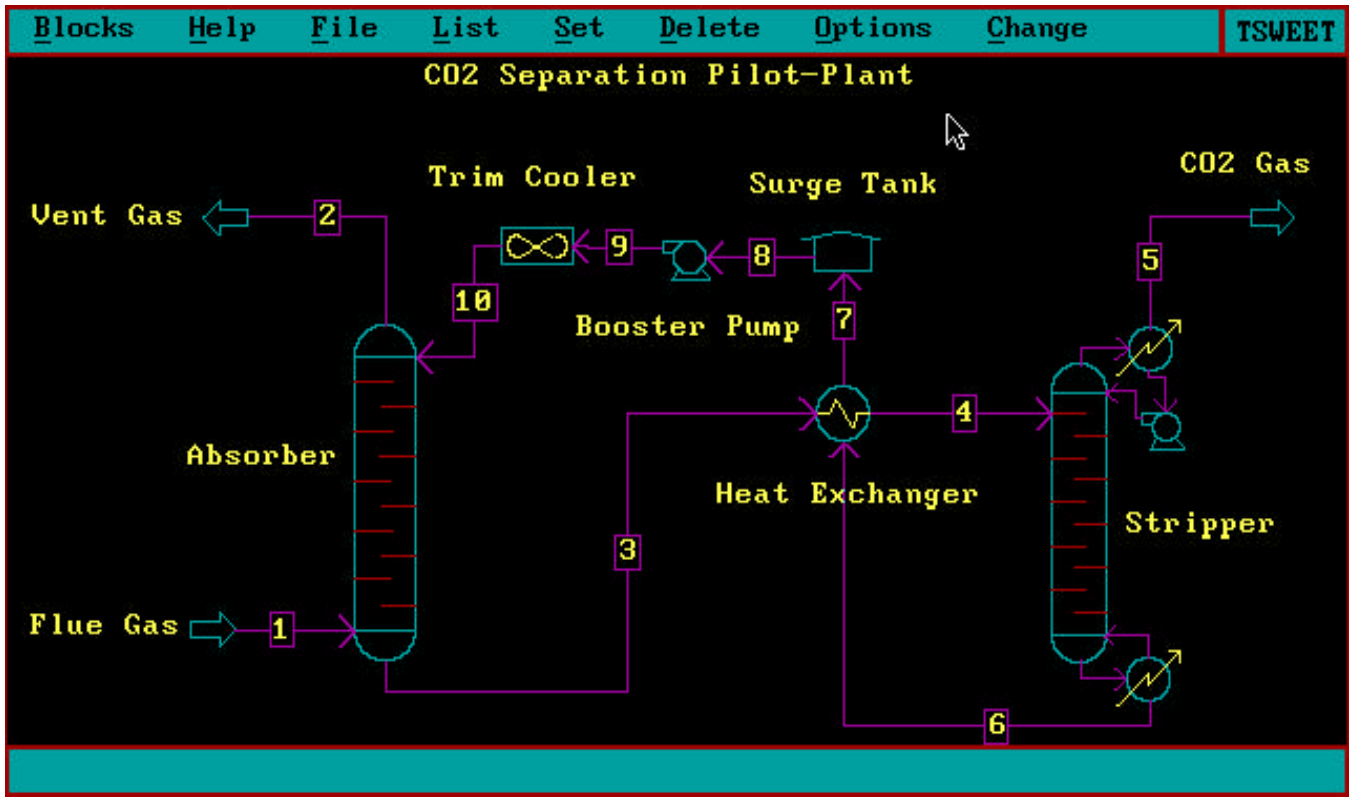


1. wetted wall column 2. water saturator
3. MFC 4. GC 5. refrigerator/heater
6. 7. gear pump 8. absorbent reservoir



Bench-Scale Apparatus for CO_2 Separation ($5Nm^3/hr$)

Simulation of Pilot-Plant using TSWEET



Condition of the Simulation

- Capacity : 2 CO_2-ton/day
- Recovery ratio of CO_2 : 90%
- Absorbent : 30 mass % MEA
- Pressure of flue gas : 150 kPa

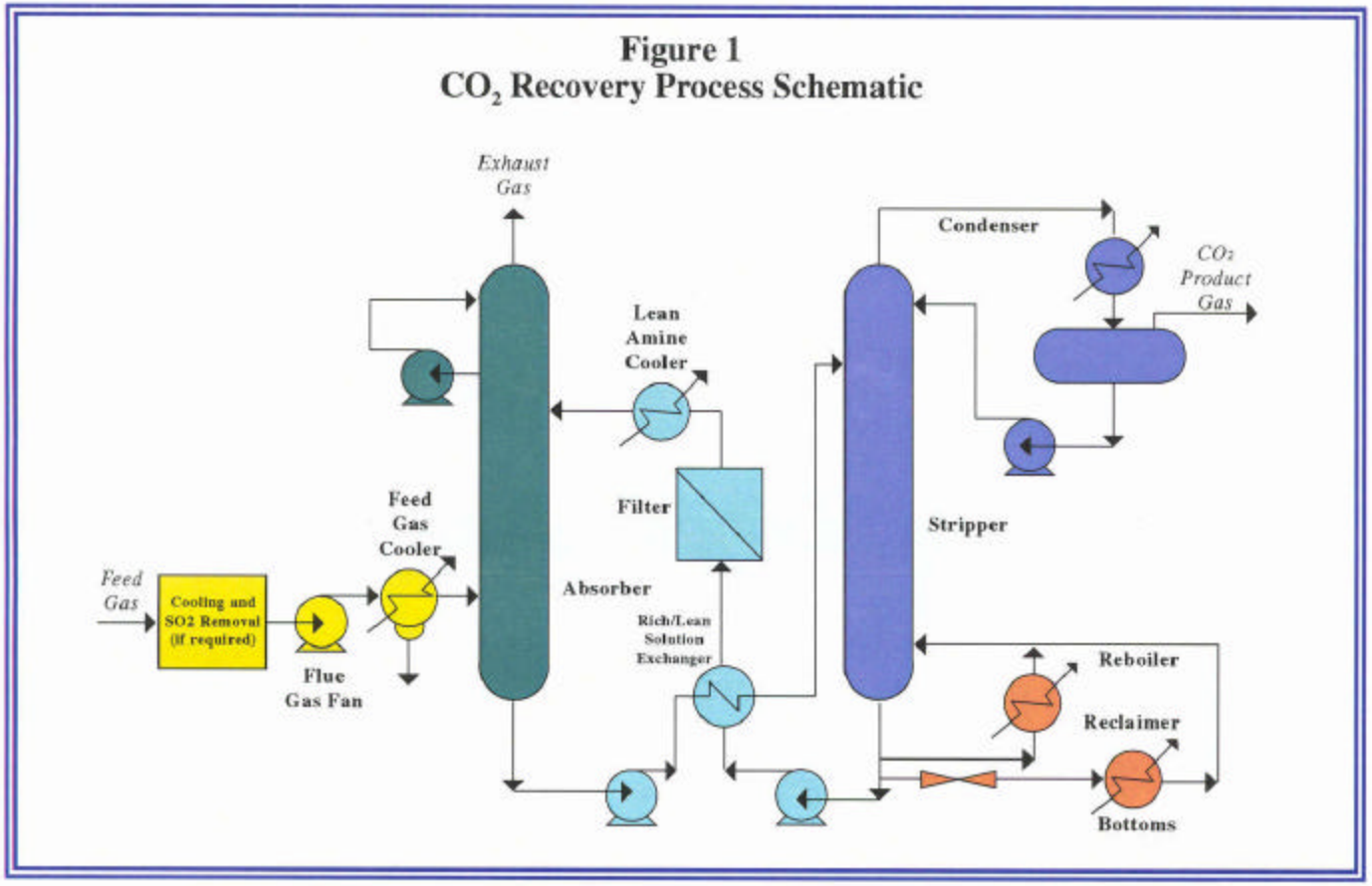
Results

- Size of Absorber : Diameter 0.4 m, Height 22 m
- Size of Stripper : Diameter 0.26m, Height 18 m
- Purity of CO_2 to be recovered : 99.95%

CO_2 Separation Pilot Plant at KEPRI

Period of the construction : ’01.01 - ’01.12 (12 months)
Contractor : Daelim Industrial Co. (Korea)
Site : Seoul LNG thermal power plant #5 (250 MW)
Capacity : 2t-CO_2/day (600 Nm^3/hr of flue gas)
Method of capture : Chemical absorption by alkanol amine based solvent
Purity of CO_2 to be recovered : > 99%
Recovery ratio of CO_2 : > 90%

Process Schematic



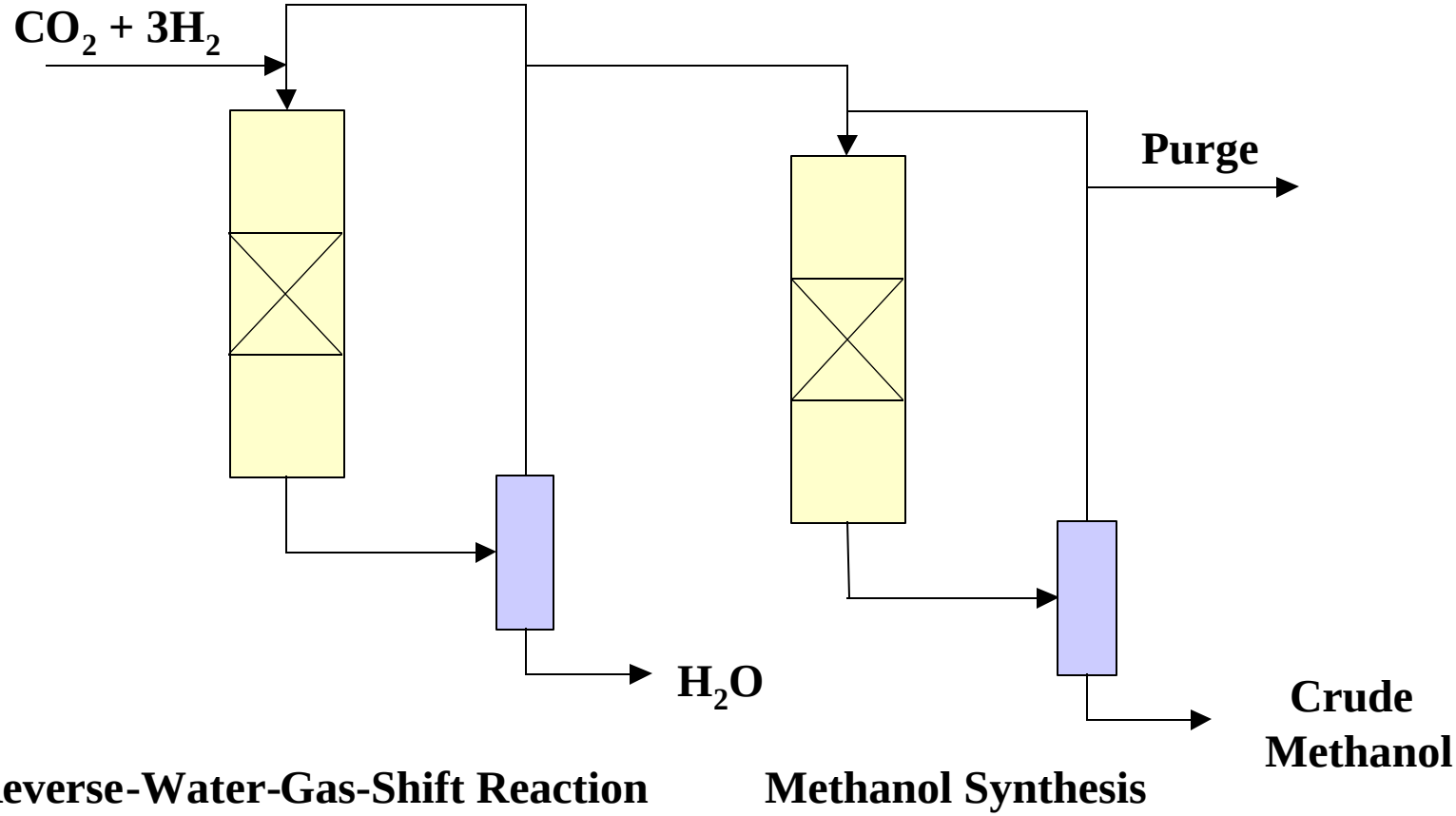
CAMERE Process

(Carbon dioxide Hydrogenation to Form Methanol via Reverse-Water-Gas-Shift Reaction)

1. $CO_2 + H_2 \xleftrightarrow{\text{cat}} CO + H_2 + H_2O$
2. Elimination of Water
3. $CO + H_2 + H_2O \longleftrightarrow CH_3OH$

Advantage : Enhancement of process efficiency due to the elimination of H_2O which could be used as an inhibitor

Diagram of CAMERE Process



CAMERE Pilot Plant (5 kg/day)

Future Works

1. Development of new absorbents with the high efficiency and stability to surpass classical amine-based absorbents
2. Study on the optimal operating conditions of the pilot-plant
3. Study on the operating cost reduction
4. Study on the thermal degradation, corrosion and foaming of absorbent
5. Conversion of CO_2 separated from flue gas into methanol